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ORIGINAL ARTICLES

EFFECT OF IRRIGATION AND GROWING RICE ON SALINE SOILS

I. MANGANESE, NITROGEN AND PHOSPHATE STATUS OF SOIL

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(Received for publication on 25 November 1946)

THE Punjab being an agricultural province its prosperity mainly depends upon the crops it can produce. Since the introduction of canal irrigation there has been a considerable change in the soil and the fertility and crop yields have been affected adversely.

One of the main characteristics of the soil of this area is its tendency to develop salinity, due to which the land becomes unsuitable and uneconomical for cultivation. The deteriorated land locally known as *thur* has a white incrustation and becomes loose and fluffy if sodium sulphate is present in excess and broken up at the surface if sodium chloride predominates. Vast area has thus gone out of cultivation which contains sodium salts evenly or unevenly distributed in the soil profile. Although this has mainly appeared in areas with high water-table still fields with low water-table have also been badly affected.

The formation and reclamation of *thur* lands by irrigation and paddy cultivation has been dealt with by Mehta [1940], Taylor [1940] and the usual method of reclamation is summarized below:

The fields are first levelled, wherever necessary, and the irrigation is commenced about the 15th April. The water is allowed to stand 3.0 in. to 4.0 in. deep, for about two and a half months. During this period it has been observed that the conductivity of the water standing over the field falls gradually. The field is then ploughed and the rice seedlings are transplanted. The general *varabandi* system in this province is worked weekly and 3.0 in. of irrigation is usually given on each turn. The total amount of water used for leaching and for growth of one rice crop is about seventy inches. The rice is harvested in the month of October, followed by a predetermined rotation of crops.

It is evident that during the reclamation there would be a number of soil reactions taking place. The fertility of the soil which depends upon various factors is an essential condition which must not deteriorate during reclamation processes. The present paper deals with the effect of reclamation on the nutritive elements, *i.e.*, manganese, nitrogen and phosphorus.

EXPERIMENTAL

(a) Sampling

Soil samples were taken from three different villages on Upper Chenab Canal. The first sampling was done before reclamation. The place from where a sample was taken was marked by noting the perpendicular distances from the two adjoining boundaries of the field. The samples were taken by the help of soil auger which could make a bore of 3 in. and could be pushed into the soil by rotation. Samples representing each foot were collected up to 2 ft. depth from one acre area. After reclamation the sampling was repeated taking care that the spot selected was as near as possible from where the previous sample was collected.

(b) Preparation of samples for analysis

The soil samples were sun-dried, powdered, sieved through 2 mm. sieve and properly labelled.

(c) Analysis

The following is a brief description of the technique adopted for analysis:

1. Manganese was determined by the Bismuthate method [*Bulletin Imperial Bureau of Soil Science*, 1937].

2. The Phosphates were extracted from soils by Trug method [1930] and Deniges technique as elaborated by Chapman [1932] was used to develop colour. The colorimetric comparison was made by Klett colorimeter against colours developed with standard phosphate solutions.
3. Nitrogen was determined by Kjeldahl's method as modified by Bal [1925]. Nitrate was determined by the usual official method of phenol-di-sulphonic acid.

The results of the average values for all the plots before and after reclamation for the first and second foot are given in Table I.

TABLE I

The average values of manganese, nitrogen, nitrate and phosphate contents of soils before and after reclamation

Serial No.	Soil nutrient	0—1.0 ft. (First foot)		1.0 ft.—2.0 ft. (2nd foot)	
		Before reclamation.	After reclamation.	Before reclamation.	After reclamation.
1	Manganese content in m.e. per 100 gm. of soil .	3.3	2.6	3.6	3.2
2	Nitrogen content as nitrogen in milligrams per 100 gm. of soil	34.0	15.9	27.4	15.6
3	Nitrate content as sodium nitrate in milligrams per 100 gm. of soil	5.3	3.5	4.5	1.8
4	Phosphate content as P_2O_5 in p.p.m.	14.3	12.6	15.0	10.9

DISCUSSION

Effect of reclamation on manganese content of soil

The average values of manganese content in m.e. per 100 gram of soil, in the first and second foot before and after reclamation are given in Table I. There is a decrease in manganese content of soil after reclamation which is more in the first foot than in the second.

In the soil, manganese is probably present in the form of dioxide or its hydrate $Mn_2O_3 \cdot 3H_2O$. Between pH values of 7 and 9 the manganese dioxide remains insoluble [Britton, 1929]. During the process of leaching under the rice cultivation, carbon dioxide is produced in the root zone of the plants, which not only increases the rate of percolation of water but reduces the pH of the soil. It has been observed by Dastur and Kalyani [1934] that the pH value of the soil in the vicinity of the roots of the plant generally remains below 7. The pH value of the roots of the plant may be still lower. According to the observation of Puri and Uppal [1938] the pH value of a soil is decreased to about 5 in many cases depending upon the nature of soil and below 7 in all cases. The pH of carbon-dioxide solution is about 4 and therefore the pH of the soil in a solution of carbon dioxide is bound to decrease.

The manganese compound being more soluble below pH 7.0, the decrease in the manganese content of the soil after reclamation can be easily explained. The water passing through soil on reaching the root zone dissolves carbon-dioxide in which the manganese compound is soluble and is leached out.

Effect of reclamation on nitrogen content of soil

The average values of nitrogen and nitrate in the first and second foot before and after reclamation are included in Table I. The nitrogen content of the soil as well as nitrate show a considerable decrease after reclamation.

A large amount of work has been done on the absorption of nitrogen by rice plant by various workers. Nitrogen may be present in the form of ammonia or nitrate and the intake depends upon

the age of the plant. Kelley [1911] and Trelease and Paulino [1920] have shown that in the earlier stages the ammoniacal nitrogen is absorbed while, in the latter stages of the growth, the nitrate-nitrogen is preferably taken up. The loss of nitrogen from the soil bearing rice would thus be due to absorption by the plant in the first instance.

At Rothamstead [Russel, 1942] it was observed that a plot kept under irrigation, but without any crop, lost nitrogen. The loss was found to be equal to the nitrogen in the leachate, which was 25 lb. to 40 lb. per acre per annum. In the case of soil under crop the loss of nitrogen was less as the discharge of leachate decreased due to the absorption of moisture by the plants. It is estimated that after making an allowance for the absorption of nitrogen by the plants and its loss due to other agencies, the soil may lose about 70 per cent of the added quantity of nitrogen due to leaching only.

De and Pain [1936] has pointed out that under water-logged conditions or if the soil is kept submerged under water for long periods the aerobic nitrogen fixing organism is totally destroyed. This is the condition in rice cultivation when the soil remains submerged for about two and a half months intermittently.

Effect of reclamation on phosphate content of the soil

The average values of phosphate content in p.p.m. as P_2O_5 before and after reclamation are given in Table I. There is more decrease of phosphate content in the second foot than in the first foot.

Carbon dioxide is known to play an important part in the reclamation of alkali soils [Puri and Puri, 1938; Puri and Uppal, 1938]. Puri and Asghar [1936] worked out the carbon dioxide method of phosphate determination which corresponds to natural conditions in the field. The pH value of the solution of carbon dioxide is about 4. The carbon dioxide produced at the roots of the plant, therefore, plays the following role:—

1. It lowers the pH value.
2. It deflocculates the dispersed soil and increases the rate of percolation.
3. It dissolves the available phosphates of the soil.
4. It brings more of the exchangeable sodium of the soil into solution.

The availability of phosphorus for rice plants depends upon the amount of soluble phosphorus. It has been observed by Bartholomew [1930] that flooding of soils causes fixation of phosphorus and, as it becomes insoluble, its availability to plant decreases. Further that the rice soils generally do not respond to phosphatic manures. This observation was made in regions where irrigation water contained a high amount of basic material.

The water used for reclamation of plots under discussion was taken from Upper Chenab Canal, the analysis of which is given in Table II. The water does not contain any aluminium or iron oxide. Hence the deficiency caused in the available phosphorus, cannot be attributed to the conversion of soluble phosphorus to insoluble one by heavy basic ions. Thus the depletion in phosphorus can only be explained as a result of the effect of carbon dioxide produced by the roots of rice plants. This conclusion is supported by McGeorge [1933, 1935] who has pointed out that carbon dioxide is an important factor in governing the pH and solubility of phosphorus in the soils.

TABLE II

The results of analyses of the Upper Chenab Canal water (at Chichokimalian)

(All values expressed in part per 10⁵)

1	Calcium sulphate	nil
2	Calcium carbonate	nil
3	Calcium bicarbonate (given as calcium carbonate)	10.00
4	Calcium chloride	nil
5	Sodium sulphate	11.40
6	Sodium carbonate	nil
7	Sodium bicarbonate (given as sodium carbonate)	1.06
8	Sodium chloride	2.92
9	Total	25.38
10	Conductivity	275

The Punjab soils are generally light, the clayey portion overlying a sandy stratum, in which the water table is situated. The depth of clayey layer is different at different places. The percolation of water is an easy process through such profiles. The irrigation water passing through the root zone of the rice plant dissolves carbon dioxide and consequently the available phosphorus is decreased. As the success of reclamation process depends on a higher rate of percolation, this would be accompanied with a higher rate of removal of available phosphorus.

SUMMARY

During the process of reclamation the soil loses very important nutrient elements like manganese, nitrogen and phosphorus.

To maintain fertility it would be necessary to manure the soil after rice cultivation with a leguminous crop which would supply requisite amount of these nutrients.

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LEAF MID-RIB STRUCTURE OF SUGARCANE AS CORRELATED WITH RESISTANCE TO THE TOP-BORER (*SCIRPOPHAGA NIVELLA*. F)*

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(Received for publication on 27 February 1947)

(With Plates XII to XIV)

AMONG the borers which attack the sugarcane crop in India, the one which causes the greatest damage is the top-borer, *Scirpophaga Nivella* F. This pest is found in all the sugarcane growing parts of India. The loss caused by this borer is considerable, amounting to even 70 per cent of the crop at the time of harvest in bad cases. Canes attacked by this pest get dry and stunted and 'often have a bunchy top owing to the upper side buds developing into branches'. Moreover, many of the young shoots are killed and prevented from growing into millable canes. During the time of harvest, millable canes attacked by this pest show an average loss of 20 per cent in weight. The canes are attacked even from the time the internodes begin to appear.

The adult is a moth which lays eggs in masses covered with hairs on the sugarcane leaf. The larvae hatching out of the eggs bite into the lower surface of the mid-rib of an 'upper almost fully unfurled leaf' a few inches above the base. Then they burrow into the mid-rib down to the base of the leaf where the leaf is in contact with the shoot and then bite their way into the shoot and kill the main shoot. So the plant either completely perishes or develops side shoots and gets stunted in growth.

REVIEW OF LITERATURE

Very little work has been done on the subject relating to the factors conducive to the resistance of a variety to the top-borer.

Hazelhoff [1929, 1932] made a study of the hardness of the growing point or spindle of *P.O.J.* 2878 and *E.K.* 28. He found the growing point of *P.O.J.* 2878 to be softer than that of *E.K.* 28. He expressed the belief that *E.K.* 28 is more resistant to the top-borer (*Scirpophaga aurifolia* Zell var. *intacta* Sn.) than *P.O.J.* 2878 because the growing point of *E.K.* 28 is harder than that of *P.O.J.* 2878 and hence the newly hatched larva has greater difficulty in effecting entry into *E.K.* 28. He found the top-borer damage to be inversely correlated with the moisture supply.

Hard [1932] was of opinion that the resistance of a variety to top-borer depended upon the dry substance and hence hardness of the growing points. According to him, *P.O.J.* 2878 is much preferred by the top-borer *Scirpophaga aurifolia* Zell var. *intacta* Sn. to other varieties grown in the same field, because the growing point of this variety was more delicate and tender than that of others. He felt that the top-borer attack was inversely proportional to the dry substance content of the growing point.

Isaac [1939] after extensive field observations of cane shoots attacked by the top-borer, *Scirpophaga Nivella* F., found that certain varieties of sugarcane are definitely more resistant to the pest than others. He was of opinion that the resistant varieties have strong and hard mid-ribs, whereas those which are attacked possess weak mid-ribs as indicated by drooping leaves. 'If a larva cannot get into the one particular leaf out of the whole bunch of leaves, it perishes, and what is more important is that, if this particular leaf has a strong mid-rib, the larva is unable to pass into the mid-rib within a certain period from the time of hatching and it perishes for want of food and shelter.' When one larva attacks a plant usually no other larva tries to get into the same plant afterwards.

According to Isaac proof was also available from general observations in sugarcane tracts and from experimental cultivation of different varieties that few top-borers attack varieties of sugarcane like *Co.* 331, *Co.* 356, *Co.* 421, etc., with strong mid-ribs. Some varieties with weak mid-ribs like *Co.* 213, *Co.* 312, *Co.* 313, etc., are badly attacked and reduced to 'bunchy leafy grossy clumps'.

* Part of the thesis approved for the degree of Master of Science of the Madras University

This observation of Isaac naturally attracted attention and the present study was undertaken with a view to finding out whether there is any correlation between the resistance of a variety and the hardness of its leaf mid-rib.

GENERAL DESCRIPTION OF MID-RIB ANATOMY

The anatomy of the mid-rib in sugarcane is dealt with here in general, as it will facilitate proper understanding of the whole problem (Plate XII, fig. 1).

The upper and lower epidermis of the mid-rib possess a layer of cuticle which is more prominent on the lower epidermis. The upper epidermis is even whereas the surface of the lower is ridged. Inside the lower epidermis there is a row of vascular bundle arranged parallel to each other. The vascular bundles are of three different sizes, small, medium and big. These bundles occupy positions against the ridges of the epidermis. The bundle sheaths of these vascular bundles extend to the epidermis. Between the vascular bundles, *i.e.*, against the grooves are thin-walled mesophyll cells containing chloroplasts. Stomata are found only in the grooves. In some varieties there are rows of bristles lining the groove and pointing inwards. The size of the individual bundles and the nature of the sheath vary with the varieties.

Inside this outer row of bundles, there is another row of bigger bundles, also arranged parallel to each other. The bundles comprising this row are of one size and bigger than the bundles of the outer row. They are farther apart from one another than the bundles of the outer row.

Immediately below the lower epidermis there are 3-4 layers of sclerenchymatous cells. Thin-walled cells of the ground tissue occupy the space between these layers and the second row of big vascular bundles.

It will be seen from this general anatomy of the mid-rib that the mechanical tissues, *viz.* the vascular bundles with their bundle sheaths that give rigidity and hardness to the mid-rib are found on the ventral (lower) side, the dorsal (upper) side being softer and consisting of mostly thin-walled cells. It is to be noticed that the larvae of the top-borer make their entry into the mid-rib by boring on the ventral side which is harder than the dorsal. This may be because the eggs are laid on the under surface of the leaf to protect them against natural enemies.

MATERIAL AND METHODS

Mid-rib material of resistant and susceptible varieties were obtained from the Imperial Sugarcane Breeding Station, Coimbatore, situated in Tropical India and also from its Sub-Station at Karnal (Punjab) situated in the sub-tropics. They were preserved in formalin-acetic-alcohol. Wherever possible mid-ribs having the bore made by the larva were studied. In other cases, mid-ribs were obtained from the lowest almost unfurled leaf of the leaf spindles, as it was known that the larva bores into the mid-rib in such leaves. The crop was five months old at the time of study, a time at which the attack of the pest is severe. The study was carried out for two seasons.

Studies at the Sugarcane Sub-Station, Karnal (Punjab), to establish correlation between the counts of egg masses of the top-borer on the leaf of a variety and their reaction to the attack of the pest have resulted in negative results. Hence in the present study no attempt has been made for investigations along those lines.

The figures for the percentage of dead hearts given in Table II were obtained from Karnal as also the mid-ribs of the varieties concerned. As stated before, the attack of this pest is severe only in North India. At Karnal only the popular canes are grown and as such the percentage of dead hearts could be obtained only for these varieties. Many of the other varieties for which the lignification figures are given and for which no percentage of dead hearts have been recorded are only grown at the Sugarcane Breeding Station, Coimbatore, where there is very little incidence of this pest. As such the percentage of dead hearts could not be determined for them. But their mid-rib structure was studied in order to facilitate selection of suitable parents for imparting a hard mid-rib to the progeny.

First to study the method of entry of the larva into the mid-rib, cross sections were taken through the centre of a puncture made by the borer. On examination it was found that the larva bites through a portion of the mid-rib containing 7-8 of the vascular bundles of the outer row. The average distance

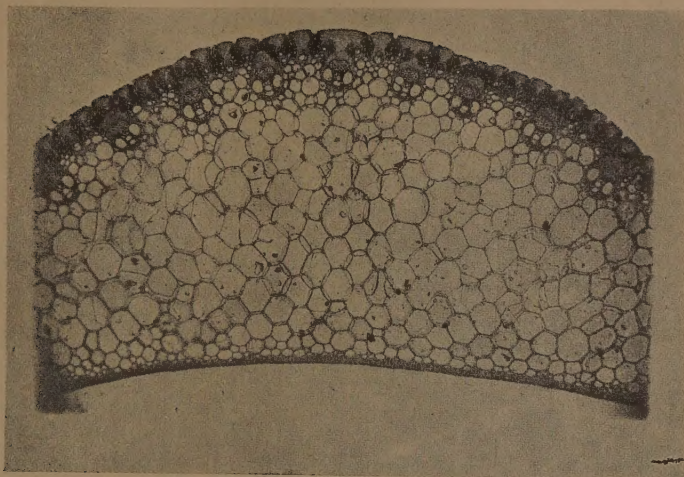


FIG. 1. Transverse section of leaf mid-rib of *Co. 312* unaffected.

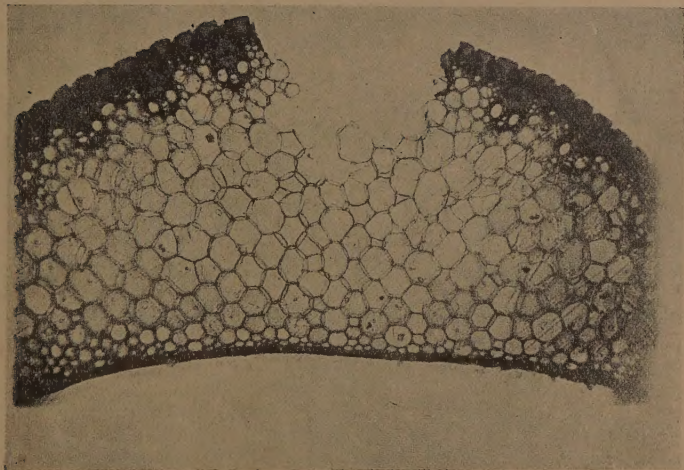
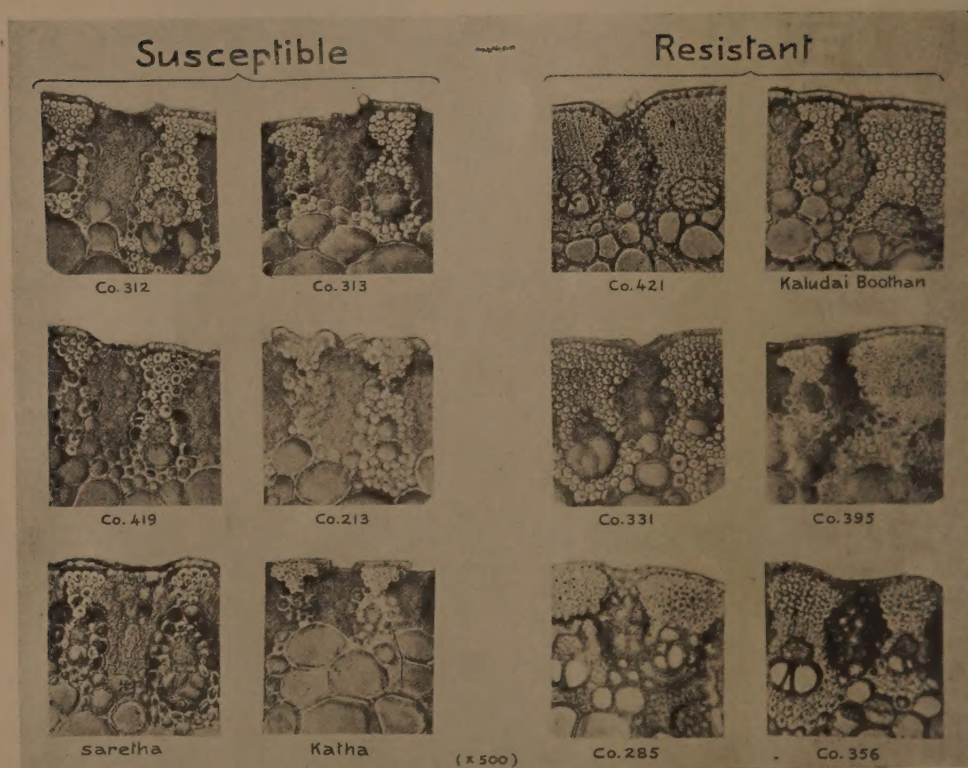


FIG. 2. Transverse section of leaf mid-rib of *Co. 312* affected and the top borer showing the extent of damage to the vascular tissues.



Cross section of midribs showing the resistant varieties with more lignified and better developed bundle sheath than those of the susceptible varieties.

which separate the vascular bundles of the outer row even in very susceptible varieties is not more than 0.06 mm. Since the larva is more than half a millimetre in size, it cannot pass into the mid-rib between two neighbouring bundles, i.e. through the soft mesophyll tissue. It must bite through a number of bundles to get into the mid-rib. In the photograph (Plate XII, fig. 2) is reproduced a cross section through the centre of a puncture made by the borer. Some indication is given of the number of bundles eaten by such penetration.

The thickness and nature of the bundle sheath should, therefore, play a prominent part in facilitating or checking the entry of the larva. Thus, if the sheath is well developed and its cells are thick-walled, the mid-rib will be rendered hard and the larva will find it difficult to eat its way through. On the other hand if the bundle sheath is not well developed, the mid-rib will be soft and the variety is liable to be attacked by the pest.

The number of vascular bundles alone may not be of great value in determining the degree of resistance of a variety since; though their number per unit area may be large, they may be very small with a poorly developed bundle sheath. This is the case in some of the susceptible varieties.

As lignification of tissues is an obvious factor in its hardness, the various resistant and susceptible varieties were next examined for this character. At first eight varieties, four resistant and four susceptible to the top-borer were taken up for study. Cross sections of the mid-rib were taken, stained in Safranin and Light green and permanent mounts made in Canada balsam. The total amount of lignification per unit area of the mid-rib was calculated as follows. The number of vascular bundles with the bundle sheath in one square millimetre of the mid-rib was drawn out on a paper with the help of a camera lucida. The area of the bundles was measured with a planimeter. This figure does not give the actual amount of lignification, as difference is noticed among the varieties in the thickness of the bundle sheath cells. So the area of the cavities or lumens of the cells in one square millimetre of the mid-rib was worked out. The total amount of lignification was obtained by finding the difference between the total area of the vascular bundles and the total area of the cavities of the sheath cells. The figures worked out brought out a distinct correlation between the two characters. All the four resistant varieties had a more lignified and better developed bundle sheath than in the four susceptible varieties (Plate XIII).

To find out whether there are any other anatomical factors correlated with the resistance of a variety, the following characters were also studied:

- (1) The number of cork and silica cells per unit area of the lower epidermis of the mid-rib.

This character is of some importance since cork and silica cells contribute to the hardness of the mid-rib.

- (2) The number of bristles per unit area of the lower epidermis of the mid-rib.

The more the number of bristles the less may be the chance of the larva attacking the variety since the bristles will offer resistance.

Peelings of the epidermis were taken by the method adopted by Artschwager [1930]. They were stained in chloro-iodide of zinc and the number of cork cells, silica cells and bristles per unit area calculated.

The amount of lignification in the mid-rib has been worked out for about fifty varieties. These include the different species of *Saccharum*, viz. *S. officinarum*, *S. spontaneum*, *S. Barberi*, *S. sinense* and *S. robustum* and interspecific and intergeneric hybrids between *Saccharum* and other general.

OBSERVATIONS

Table I gives the list of varieties and the amount of lignification for 100 sq. cm. of the mid-rib.

Absolutely according with the observation that the resistance of a variety depends on the intensity of lignification of the mid-rib, the examination of the data on the percentage of attack of the top-borer has shown that there is correlation between the degree of resistance of a variety and the amount of lignification in the mid-rib.

The figures in Table II demonstrate the relation between the lignification of the mid-rib and top-borer infestation in the varieties for which the percentage of dead hearts are available.

TABLE I

List of sugarcane varieties with the amount of lignification in their mid-ribs per 100 sq. cm. of the area of mid-rib

No.	Name of variety	Amount of lignification in sq. cm.
SACCHARUM OFFICINARUM		
1	Kaludai Boothan	20.277 \pm 0.0525
2	D. 74	18.662 \pm 0.0401
3	Vellai	17.272 \pm 0.0925
4	Black Cheriton	16.928 \pm 0.0725
5	Greensport	16.917 \pm 0.0274
6	Striped Mauritius	15.468 \pm 0.0315
7	B. 3412	12.527 \pm 0.0794
SACCHARUM SPONTANEUM		
1	S. spontaneum, Coimbatore	13.123 \pm 0.0025
2	S. spontaneum, Java	9.912 \pm 0.0524
SACCHARUM BARBERI		
1	Chunnee	10.372 \pm 0.0721
2	Saretha	10.012 \pm 0.0675
3	Katha	9.312 \pm 0.0824
4	Mungo	9.311 \pm 0.0628
5	Nargori	9.279 \pm 0.0575
6	Sunnabile	9.112 \pm 0.0829
SACCHARUM SINENSE		
1	Ula	10.155 \pm 0.0728
2	Pansahi	11.212 \pm 0.0825
SACCHARUM ROBUSTUM		
1	N. G. 251	14.011 \pm 0.0529
ERIANTHUS ARUNDINACEUM		
1	Glongong	15.862 \pm 0.0728
HYBRIDS		
1	Co. 205	14.315 \pm 0.0675
2	Co. 213	10.525 \pm 0.0565
3	Co. 214	10.728 \pm 0.0665
4	Co. 229	9.825 \pm 0.0525
5	Co. 244	15.725 \pm 0.0785
6	Co. 285	18.674 \pm 0.0782
7	Co. 291	9.765 \pm 0.0594
8	Co. 292	12.822 \pm 0.0815
9	Co. 312	10.510 \pm 0.0357
10	Co. 313	10.414 \pm 0.0685
11	Co. 318	12.624 \pm 0.0578
12	Co. 331	20.010 \pm 0.0625
13	Co. 356	19.121 \pm 0.0545
14	Co. 385	10.218 \pm 0.0279
15	Co. 395	19.128 \pm 0.0712
16	Co. 396	10.107 \pm 0.0527
17	Co. 419	10.374 \pm 0.0725
18	Co. 421	20.715 \pm 0.0482
19	P.O.J. 213	13.911 \pm 0.0824
20	P.O.J. 2364	13.728 \pm 0.0725
21	P.O.J. 2725	14.712 \pm 0.0528
22	P.O.J. 2878	19.676 \pm 0.0948
23	B.h. V (Bamboo hybrid)	14.129 \pm 0.0595
24	B.h. IX (Bamboo hybrid)	10.917 \pm 0.0729
25	Sorghum halepense, Palestine	9.012 \pm 0.0628



Development of lignified tissue in a number of hybrids and their parents.

TABLE II

Correlation between the amount of lignification in the mid-rib and top-borer infestation

No.	Name of variety	Amount of lignification in sq. cm.	Percentage of dead hearts
1	Co. 396	10.017±0.0527	45.10±0.275
2	Co. 385	10.218±0.0279	42.20±0.321
3	Co. 419	10.374±0.0725	36.20±0.228
4	Co. 312	10.510±0.0357	36.10±0.225
5	Co. 213	10.505±0.0565	34.60±0.349
6	POJ. 2878	19.676±0.0948	21.10±0.531
7	Co. 331	20.010±0.0625	19.60±0.421
8	Co. 421	20.715±0.0482	18.30±0.258

From a study of the anatomy of the mid-rib of *Saccharum hybrids*, and their parents, evidence is available that this particular anatomical character, viz. marked lignification of the mid-rib can be inherited and passed on to the progeny by a suitable choice of parents. This will be clear from Table III wherein is given the area of lignified tissue per 100 sq. cm. in a certain number of hybrids and their parents (Plate XIV).

TABLE III

The area of lignified tissue in a number of hybrids and their parents

No.	Name of pistil parent with amount of lignification in sq. cm.	Name of hybrid with amount of lignification in sq. cm.	Name of pollen parent with amount of lignification in sq. cm.
1	<i>Vellai</i> Good lignification . . . (17.272)	<i>Vellai</i> × <i>D. 74</i> Good lignification . . . (17.787)	<i>D. 74</i> Good lignification . . . (18.662)
2	<i>Vellai</i> Good lignification . . . (17.272)	<i>Vellai</i> × <i>Sorghum</i> Moderate lignification . . (13.142)	<i>Sorghum</i> Poor lignification . . . (10.175)
3	<i>Vellai</i> Good lignification . . . (17.272)	<i>Vellai</i> × <i>Narenga</i> Good lignification . . . (16.827)	<i>Narenga</i> Poor lignification . . . (10.292)
4	<i>Vellai</i> Good lignification . . . (17.272)	<i>Vellai</i> × <i>S. robustum</i> Good lignification . . . (18.072)	<i>S. robustum</i> Moderate lignification . . (14.011)
5	<i>Vellai</i> Good lignification . . . (17.272)	<i>Vellai</i> × <i>S. halepense</i> Poor lignification . . . (9.715)	<i>S. halepense</i> Poor lignification . . . (9.012)
6	<i>P.O.J. 2878</i> Good lignification . . . (19.676)	<i>Co. 421</i> Good lignification . . . (20.715)	<i>B. 3412</i> Poor lignification . . . (12.527)
7	<i>Co. 213</i> Poor lignification . . . (10.525)	<i>Co. 331</i> Good lignification . . . (20.010)	<i>Co. 214</i> Poor lignification . . . (10.728)
8	<i>Co. 213</i> Poor lignification . . . (10.525)	<i>Co. 312</i> Poor lignification . . . (10.638)	<i>Co. 244</i> Fair lignification . . . (15.725)

The study of the number of cork cells, silica cells, and bristles per unit area in the epidermis revealed no correlation between any of these characters and the reaction of a variety to top-borer infestation. This study as at first confined to the eight varieties whose percentages of infestation is known, and when it failed to give any correlation, the study was not proceeded with for the other varieties. In Table IV is presented the average number of cork cells, silica cells and bristles per sq. mm. of mid-rib in the eight varieties together with the percentage of dead hearts.

TABLE IV

The average number of cork cells, silica cells and bristles per sq. mm. of mid-rib with the percentage of dead hearts

No.	Variety	Number of cork cells per sq. mm.	Number of silica cells per sq. mm.	Number of bristles per sq. mm.	Percentage of dead hearts
1	Co. 396	28±0.0674	10±0.0615	12±0.0835	45.10±0.275
2	Co. 385	15±0.0879	4±0.0389	5±0.0639	42.20±0.321
3	Co. 419	32±0.0749	3±0.0461	..	36.20±0.228
4	Co. 312	30±0.0853	10±0.0718	20±0.0640	36.10±0.225
5	Co. 213	27±0.0628	14±0.0788	16±0.0674	34.60±0.349
6	P.O.J. 2878	25±0.0520	6±0.0537	..	21.10±0.531
7	Co. 331	30±0.0769	4±0.0519	4±0.0492	19.60±0.421
8	Co. 421	35±0.1125	10±0.0369	20±0.0769	18.30±0.258

DISCUSSION

The above study and the collected figures prove that there is correlation between the intensity of lignification in the mid-rib of a variety and its resistance or susceptibility to the top-borer and that the top-borer infestation generally increases with the lessening of the lignification in the mid-rib. No variety seems to be completely immune to the attack of this pest and so the values are only comparative. Certain cane varieties are markedly more heavily infested by the top-borer than others.

Since it is the amount of lignification that decides the hard or soft nature of the mid-rib, the results of this study are in agreement with the view put forth by Isaac that varieties with strong mid-ribs are less liable to be attacked than those with soft mid-ribs 'and a strong mid-rib as a characteristic will afford the variety that has it, resistance to this serious pest'. It is obvious that the presence of good lignification in the mid-rib will make it hard and prove to be an obstacle to the entry of the larvae.

The resistant varieties have the bundle sheaths well developed and more prominent than the susceptible varieties. Thus in *Kabudai Boothan*, Co. 331, Co. 356 and Co. 421, the bundle sheath is decidedly thicker and more prominent than in Co. 213, Co. 313, Co. 419, *Saretha*, etc. As already explained, the number of bundles alone is not enough to determine the degree of resistance of a variety. For example, in Co. 419, the number of bundles is greater than in Co. 421; but the latter is twice more resistant to the top-borer because in Co. 419 the bundle sheath is poorly lignified.

Generally the thick canes have a good amount of lignification in their mid-ribs, whereas the thin Indian canes have poorly lignified mid-ribs. So it may be predicted that the liability of infestation is likely to be greater in thin canes than in thick canes. From Table I it is clear that thick canes like *Kabudai Boothan*, D. 74, *Black Cheribon*, *Greensport*, etc., have very well lignified mid-ribs. The thin canes belonging to the various group under *S. Barberi* and *S. sinense*, viz. *Saretha*, *Katha*, *Mungo*, *Nargori*, *Pansahi*, etc. have poor lignification in their mid-ribs.

The wild *Saccharums*—especially the *spontanearums*—have been used to a great extent in breeding both at Coimbatore and Java as they have been found to be resistant to adverse environmental conditions and certain pests and diseases. The study of the mid-rib of some of these reveals that they have poorly lignified mid-ribs. Hence they may not be of use in breeding types resistant to this particular pest.

In *Sorghum* which has been used as one of the male parents in the intergeneric cross with sugarcane, the mid-rib is poor in its lignification. In bamboo which is the male parent in the sugarcane-bamboo crosses, there is a considerable amount of lignification in the mid-rib. Practically the whole of the mid-rib is lignified on both sides, thus making it very hard.

The studies have shown that this particular anatomical character, viz. good lignification of the mid-rib can be inherited. This will be clear from Table III. A good number of the hybrids has inherited this desired anatomical character. In some cases it is from both the parents as in the cross

between *Vellai* and *D. 74*, wherein both the parents and the hybrid have very well lignified mid-ribs. In some cases it is from one of the parents, as in *Co. 421* wherein the good lignification of *P.O.J. 2878* is noticed to the exclusion of the poor lignification in *B. 3412*. In some cases the hybrids have inherited the poor lignification of one of its parents, the good lignification of the other being not inherited as in the seedling of the cross *Vellai* \times *Sorghum halepense*. In the case of *Co. 331*, the parents have poorly lignified mid-ribs, whereas it has a very well lignified mid-rib. This character has evidently been inherited from one of its remote ancestors, *Kaludai Boothan*.

Out of the two baniboo hybrids studied, *B.h.V* shows moderate lignification in its mid-rib whereas *B.h.IX* has a poorly lignified mid-rib. The hybrids did not inherit the very good lignification of the male parent. It is possible by back crossing the hybrids with bamboo to bring in the very strong mid-rib of the latter. In that case the hybrids might prove very resistant to the top-borer.

In the nature of inheritance of this anatomical character variation is met with even in hybrids which have the same female parent. In the crosses obtained with *Vellai* as female parent and with different male parents, some of the hybrids show good, some moderate and others poor lignification in their mid-ribs. This will be apparent from Table III and Plate XIV. This wide variation is characteristic of sugarcane hybrids and is to be expected since sugarcane is strongly heterozygous and each seedling a potentially new variety in itself. The question whether lignification of mid-rib is a dominant or recessive character cannot be answered with any degree of certainty due to the complex nature of sugarcane hybrids. Even in the F_1 generation it has been found that in one case, viz. *Co. 285* [*Saccharum officinarum* (*Vellai*) \times *Saccharum spontaneum*, Coimbatore] the lignification is dominant, in another, viz. *Co. 291* [*Saccharum officinarum* (*Kaludai Boothan*) \times *Saccharum spontaneum*, Coimbatore] it is recessive while in the third, viz. *Co. 205* [*Saccharum officinarum* (*Greensport*) \times *Saccharum spontaneum*, Coimbatore], it is intermediate. The dominance or recessiveness of the character depends on the genetic background and the particular varieties used in combination. It could at best be said that the introduction of a parent with well lignified mid-rib, i.e., hard mid-rib, increases the average hardness of the progeny. Since this much desired anatomical character is inheritable it is possible by suitable choice of parents to introduce into the hybrids this character and thus render them hard and resistant to the top-borer. Since the cheapest and efficient way of fighting out pests and diseases lies in the cultivation of resistant varieties, if such varieties with good lignification in their mid-ribs are brought into being by sugarcane breeders, it would be to the advantage of the sugarcane growers throughout the world.

SUMMARY

1. The object of the present study is to find out whether any correlation exists between the resistance of a variety to the top-borer (*Scirpophaga nivella* F) and the hardness of the mid-rib.
2. About fifty varieties including the different species of *Saccharum* and the interspecific and intergeneric hybrids with *Saccharum* have been studied.
3. The results show that there is a fairly close correlation between the amount of lignification in the mid-rib (the hardness of the mid-rib) and the degree of resistance of a variety.
4. Thick canes generally have good amount of lignification in their mid-ribs, while thin canes have poorly lignified ones.
5. The good lignification of the mid-rib is found to be inherited from certain parents.
6. It might therefore be possible by a suitable choice of parents to introduce into the hybrids this desired anatomical character thus rendering the mid-rib hard and resistant to the pest.

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SEASONAL HISTORY AND FIELD ECOLOGY OF THE WOOLLY APHIS IN THE KAMAUN HILLS

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THE woolly aphis, *Eriosoma lanigerum* Hausman, a pest of apple trees all over the world, is believed to have been introduced into India on imported nursery stock. The first record of its occurrence in this country dates back to 1889 when it was observed damaging apple trees at Conoor in south India [Misra, 1929] and the next record appears to be its mention in the *Report of the Kamaun Government Gardens* for 1909-10, about which time it was also observed in the Simla district. Presumably the pest entered these localities much earlier. At present the woolly aphis is known to occur in several parts of the Indian region, viz. Kashmir, North West Frontier Province, the Punjab, the United Provinces, Assam, Burma, Sikim and south India.

Investigations on the woolly aphis in the Kamaun hills were started at Ramgarh, District Nainital, in 1929 and later, extended to Chaubattia-Ranikhet and other areas. The information collected during 1929-44 has been sifted and such of it as has appeared new or interesting is, in part, embodied in the present paper. Much of the biology of *E. lanigerum*, which is well known, has been omitted. A paper on the methods of controlling the pest in the Kamaun hills has been published by one of us [Singh, 1942].

The life history of the woolly aphis in Kamaun does not materially differ from that in the Punjab [Rahman and Khan, 1941]. The species is confined to apple trees only, is parthenogenetic, viviparous and multi-brooded. These broad facts also accord with the observations made elsewhere. In North America and Japan, however, elm is an important alternate host plant to which the woolly aphis migrates periodically, and on which it reproduces sexually. Sexual forms of *E. lanigerum* appear in Europe and some other countries also but their progeny do not establish themselves well and hence are ineffective in aiding the multiplication of the pest. Fotedar and Kapur [1941], however, reported the occurrence of the sexual forms in Kashmir.

The woolly aphis, like other organisms, is a creature of its environment whose population is profoundly influenced by the nature of its host, natural enemies and climatic conditions. The mechanical action of wind and rain, however, appear to be negligible factors in determining the incidence or population of the pest. An attempt has been made in this paper to assess the relative values of these factors in terms of their effects on the woolly aphis population. Some observations have also been made to determine the varieties of apple, susceptible or resistant to woolly aphis attack, while a study of the behaviour of the species has thrown light on the apparent vagaries of its colonizing habits.

SEASONAL HISTORY AND HABITS

The woolly aphis attacks all aerial parts of the apple tree and, in some cases, also the parts a few inches below ground level. Adults and nymphs occur practically all the year round but during the coldest part of winter, that is, from the middle of December to the end of January, only nymphs remain, hidden in the cracks and crevices of the bark and other sheltered portions of the trees. During this period they are inactive, except that on sunny days a few of them may sometimes be seen moving from one shelter to another. They are, at this time, devoid of the waxy filaments on their bodies, a result of which they are inconspicuous. Except for this temporary suspension of activities, there is no actual hibernation by the woolly aphis in Kamaun. Even if the apple trees are simply pruned and thus some protection against cold is afforded to them, aphids of all stages remain active on them throughout the year, feed and move about and even show a certain amount of reproductive activity. In the Punjab, the woolly aphis is said to viviposit throughout the year [Rahman and

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Khan, 1941]. In Europe also it appears to have no 'true' hibernation [Greenslade, 1936]. In north America, however, the pest may hibernate in the egg and nymphal stages and, in warmer parts, oviparous females as well, on elm and apple trees [Metcalf and Flint 1939].

During February and March in Kamaun, the nymphs come out of their shelters, settle down at suitable places on the tree and start feeding. Soon after, the waxy filaments appear on their bodies and in about two weeks' time the adult stage is reached and viviposition commences. The newly born nymphs may remain close to their parents in the same colony or, if it is very crowded, may wander up and down in search of more favourable places to settle down and start new colonies. Viviposition goes on throughout the summer, autumn and early part of winter, after which it ceases; most of the adults die and the nymphs migrate to the under-ground parts or move into sheltered situations on the tree to tide over the coldest part of the winter as described before.

As happens in the Punjab, some of the aphids produced in early July are winged as also viviparous, parthenogenetic females like the wingless ones. Their number goes on increasing till about the middle of August when on a heavily infested tree the number of winged aphids may exceed that of the wingless ones. Some of the former fly to other trees and start new colonies but the progeny in such cases are usually wingless. The winged aphids gradually disappear after the middle of October. It was repeatedly observed that more winged aphids are produced on heavily infested trees than on those having fewer colonies. It is not possible to explain the precise relationship between over-crowding and the production of winged forms but, on the face of it, it appears to be a device of nature to aid in the dispersal of the aphids when once their original host trees have become over-crowded.

Migration from roots to shoots and vice versa

It has been the belief among the Kamaun orchardists that the woolly aphid migrates to the roots at the beginning of winter and crawls up to the aerial parts in early spring but this is only partially true. Actually a few nymphs can be observed migrating from the aerial parts to the roots and *vice versa* simultaneously all the year round and the pest persists on both, the aerial as well as the under-ground parts of the trees. In the Punjab, Rahman and Khan [1941] state that there is a definite, though partial, summer and winter migration at Raison and no migration whatsoever at Kulu (Sultanpur) proper.

With a view to collecting definite data regarding the movements of *E. lanigerum*, three groups of four trees each, with the aphids on shoots only, on roots only, and on both, shoots and roots, were marked out and grease-banded in May 1937 to observe the periods of their upward and downward movements. The trees, having colonies both, on shoots and roots, were grease-banded at two heights on the stem and the intervening distance was kept free of the aphids. Grease-banding was maintained throughout the following twelve months in perfect condition. Every band was examined twice a month and the aphids caught on each were counted and removed every time. The data collected during the twelve months are given in Table I.

An examination of Table I shows that, although the upward and down movements continue all the year round, there is a marked tendency for upward migration in summer and for downward migration in winter. At other times of the year the movements of the aphids appear to be indefinite. The data also indicate that, while upward and downward migrations are very probably influenced by the prevailing heat and cold, respectively, when such conditions tend towards the maximum, movements at other times are governed by other factors also than these climatic ones. Generally, only the nymphs migrate from one part of the tree to another.

Seasonal incidence

The intensity of infestation by *E. lanigerum* greatly fluctuates during the year. As soon as it starts reproducing in early spring, it is attacked by the predator, *Coccinella septempunctata* Linn., which preys on all of its stages [Lal and Singh, 1945]. In certain areas of Kamaun, this lady-bird is so effective that it hardly allows any colonies on the aerial parts of the trees between March and July. In others, infestation by the pest is generally light or heavy according as the lady-bird is scarce or abundant. After July, although the lady-birds leave the apple trees and migrate to grasses, there is not much increase in the number of the aphids as, during the rainy season, reproduction is

TABLE I
Monthly records of woolly aphis migration from shoots to roots and vice versa

Serial No. of Trees	Number of migrating aphids											
	March	April	May	June	July	August	September	October	November	December	January	February
Shoot to root	1 ..	1	..	3	■	3	8	1	7	2	6	11
	2 16	..	..	4	3	..	..	6	19	20	23	11
	3 ..	3	1	..	..	..	..	1	4	10	9	..
	4 ..	..	..	17	..	..	17	2	3	8	..	..
Root to shoot	1 ..	1	289	190	15	19	19	..	3	..	..	1
	2 10	..	69	112	63	1	38	225	131	..	..	67
	3 ..	..	119	140	30	10	..	7	17	1	..	..
	4 ..	..	43	47	..	2	2	35	266	12	..	2
Shoot to root Root to shoot	1 ..	..	325	46	47	..	200	10	7	23	66	338
	..	100	2750	328	140	4	13	9	32	1	13	2
	2 ..	..	172	88	52	3	8	6	88	64	1200	68
	..	5	825	165	500	300	..	61	69	5	..	56
3	1	..	3	3	55	1	2	85	21	8	27	100
	14	5	11	15	171	9	3	200	212	2	93	33
	..	..	18	15	7	1	3	..	14	6	..	36
	..	..	383	1062	46	1	3	2	35	2	..	153

very slow due to climatic causes discussed hereafter. It is, therefore, mainly during October, November and part of December that the incidence of the pest is highest. During this period, the climatic conditions are not unfavourable for multiplication and the lady-bird is no longer there to exercise any effective check. As stated previously, from mid-December till early spring only nymphs occur.

FACTORS AFFECTING SEASONAL HISTORY AND INCIDENCE

(i) Effect of atmospheric temperature and humidity

Observations made at Chaubattia and at Ramgarh have indicated that the reproduction of the woolly aphid is not adversely affected by atmospheric temperatures up to 90°F., which is about the maximum attained in these parts. Reproduction, however, ceases when the mean minimum temperature goes below 37°F.

A monthly census of the population of the woolly aphid on three apple trees was taken during the years 1941 and 1942-43 at Chaubattia and Ramgarh, respectively. The method adopted was to divide a tree into a number of equal parts with regard to its infestation by the woolly aphid. One of these parts was again sub-divided into smaller portions of equal size and the number of colonies as well as the number of aphids in each colony in one of these sub-divisions were counted. The population of the aphids on the entire tree was determined by appropriate multiplications. The trees were caged to keep off predators but parasitization of the aphids by *Aphelinus mali* Hald. was possible. The data are presented in Tables II and III, wherein counts of both parasitized and unparasitized aphids are given. The data show that the maximum number of aphids was recorded in May and June when the maximum temperature went above 90°F. on several days, though the monthly average was lower. The gradual decline in the number of aphids from the end of June to about September appears to be due to increased humidity as after September, with the decrease in atmospheric humidity, the number of the aphids again increased. This decrease during the rainy season can not be attributed to high temperatures as these months were cooler than May or June. The colonies inside the cages were not directly hit by showers of rain and so there was no possibility of their being washed away by rain mechanically. Parasitism by *A. mali* also appears to have made little difference in the seasonal population of the aphids since the largest number of parasites inside the three cages was recorded in May and June when the aphid population was also the highest.

TABLE II

Population of woolly aphid in relation to atmospheric temperature and humidity in 1941 at Chaubattia

Month	No. of healthy aphids	No. of parasitized aphids	Averages of		
			Maximum temperature in F.	Minimum temperature in F.	Humidity (percentage)
March	150,400	7,520	66.06	50.90	39
April	(Observations not taken)	(Observations not taken)	76.32	58.90	35
May	552,960	123,420	77.20	59.60	56
June	348,066	80,286	74.72	61.18	84
July	275,576	52,084	71.90	62.00	91
August	146,260	20,842	68.70	58.45	80
September	467,190	42,935	68.10	53.79	73
October	232,100	26,447	58.70	45.00	57
November					

TABLE III

Population of woolly aphis in relation to atmospheric temperature and humidity during 1942-43 at Ramgarh

Month	Tree No. 1.		Tree No. 2.		Averages of		
	No. of healthy aphis	No. of parasitized aphids	No. of healthy aphids	No. of parasitized aphids	Maximum temperature in F.	Minimum temperature in F.	Humidity (percentage)
April	6,699	1,168	28,812	2,486	76.60	52.30	44
May	21,060	1,252	44,880	11,505	82.60	56.20	41
June	37,720	2,338	32,604	4,302	84.50	..	58
July	1,680	350	23,970	4,753	77.00	61.00	84
August	3,230	658	5,184	825	75.20	62.20	86
September	1,408	371	2,967	724	75.10	55.80	74
October	1,512	230	3,192	425	75.50	47.30	58
November	2,744	617	1,819	492	72.20	41.70	58
December	3,024	691	1,634	420	58.80	35.50	59
January	(About the same number)				57.10	36.00	50
February	(About the same number)				61.40	38.50	60
March	(About the same number)				70.10	43.30	50

(ii) *Effect of natural enemies*

The woolly aphis in Kamaun is attacked chiefly by two predators: the larva of the Syrphid fly, *Syrphus confrater* Wied., and the beetle, *Coccinella septempunctata* Linn., and by the Eulophid parasite, *Aphelinus mali* Hald. The Syrphid larva is of little economic value but the lady-bird exercises considerable check on the pest in certain areas from early spring to the end of June [Lal and Singh, 1945]. As for the parasite, inspite of repeated attempts, it has not yet established itself in Kamaun and, therefore, its influence on the woolly aphis population has been so far negligible. An account of the behaviour of *A. mali* in Kamaun is being published separately.

(iii) *Varietal resistance of apple trees to woolly aphis attack*

In 1933, an area, containing over five thousand apple trees was marked out in an orchard at Ramgarh and every tree in that area was examined in October for woolly aphis attack. The data are summarized in Table IV.

TABLE IV

Incidence of woolly aphis attack on some important varieties of apple.

Variety	No. of trees examined	No. attacked	Percentage of attacked trees	Intensity of attack*			
				I	II	III	IV
King of Tomkin's County	662	434	65.6	46.5	16.5	2.6	..
Blenheim Orange	634	530	83.6	60.4	22.3	0.9	..
King of Pippins	332	52	15.7	9.7	4.2	1.2	0.6
James Grieve	138	39	28.3	21.0	7.3	..	..
Delicious	193	12	6.2	6.2	..	..	..
Cox's Orange Pippin	183	70	38.25	31.7	6.5	..	..
Lanes Prince Albert	79	79	100.0	72.2	24.1	2.5	1.2
Jonathan	180	69	38.3	33.3	5.0	..	..
25 mixed varieties	5641	1993	35.3	24.3	9.4	1.3	0.3

* Explanation of intensity of attack:

I. 10-15 colonies on average-sized tree.

II. 16-40 colonies on an average-sized tree.

III. More than 40 colonies but the tree still looking healthy.

IV. Tree full of new and old galls and rendered very unhealthy.

Table IV shows that, although the percentage of very heavily infested trees is very low, quite a number of them are attacked by the pest. This number excludes the trees which had only a few colonies on them and did not appear to have been affected by the attack at all. Among the commercially important varieties, Blenheim Orange and King of Tomkin's County suffer the most. From general observations, carried out for many years, the important commercial apple varieties grown in Kamaun, may be classified in one of the four groups as indicated in Table V with regard to their susceptibility to the pest.

TABLE V

Classification of apple trees with regard to their susceptibility

Highly susceptible	Susceptible	Resistant	Highly resistant
Blenheim Orange	Cox's Orange Pippin	Delicious	Northern Spy
King of Tomkin's County . .	Norfolk Beefing	Alfruston	
Banoni	Esopus Spitzenberg	Golden Pippin	
King of Pippins (young trees only) .	Newton	Rome Beauty	
	King of Pippins (grown-up trees)	Gano	

(iv) *Inter-action of apple stock and scion in regard to woolly aphid attack*

Le Pelley [1927] appears to be the only worker to attempt to discover if the resistance of apple stock to woolly aphid has any influence on the resistance of the scion worked on it. Although some of the varieties, used in his experiments as stock and scion, were not very true to the characters they represented, the results gave a fair indication to the effect that the resistance of the stock does not have a marked effect on the resistance of the scion. On the other hand, Jancke [1937] considered that the resistance of a variety is due also to an unexplained influence of stocks used for grafting edible apples. In order to obtain definite information on the subject, an experiment was conducted at Chaubattia, using only those varieties of apple whose degree of resistance to the pest was definitely known. The experiment is described below:—

Material and methods. Observations extending for several years on the relative susceptibility of most of the local and imported varieties to woolly aphid had shown Malling Type II to be highly susceptible and Merton 779 to be highly resistant. These two varieties, inter-worked as well as each grafted on itself, were planted in big tubs in the winter of 1938. Each treatment was replicated four times with one tree as the unit. All the trees were uniformly infected with woolly aphid several times between April and July 1939. Towards the end of August, large numbers of colonies developed on the aerial as well as the under-ground parts of some of the trees. At the end of October, the numbers of colonies formed on the roots and scion of each tree were counted.

The experiment was repeated in the two subsequent years and the results of the three years are summarized in Table VI.

Table VI shows clearly that the resistance or susceptibility of a variety is not affected by its union with another variety possessing the reverse characteristic. There is, however, an indication that the intensity of attack on a susceptible scion, worked on a resistant stock, is less than that on a susceptible stock. As also remarked by Greenslade [1936], this difference does not seem to be due to the imparting of any resistance to the scion by the resistant stock but to the freedom of the latter from the pest which may otherwise act as an additional and close source of infection to the scion. It follows, therefore, that by using an aphid-resistant stock the grower will not only be saved from the trouble of controlling the under-ground colonies but will also have less need to control the pest on the aerial parts.

TABLE VI

Incidence of woolly aphis on stock and scion during 1939-41

Name of scion/stock	Average No. of colonies on					
	1939		1940		1941	
	Scion	stock	Scion	stock	Scion	stock
Merton 779 } . . . . .	..	..	..	..	..	..
Merton 779 }						
Malling Type II }	4	..	22	..	7	..
Merton 779 }						
Merton 779 } . . . . .	..	4	..	48	..	46
Malling Type II }						
Malling Type II }	10	8	51	17	28	23
Malling Type II }						

(v) *Effect of different soils on the infestation of roots by the woolly aphis*

A pot culture experiment was carried out at Chaubattia to see if any of the three typical soils of the Government orchard, namely, clayey, sandy and humus-rich* made the plants more susceptible to root infection than others.

Material and method. Six plants of Malling Type II, a very susceptible variety of stock, were planted in big tubs, filled with each of the three types of the soils in the winter of 1937 (that is, 18 plants in all). Shoots of all the plants were artificially infected with the woolly aphid in April 1938. The aerial parts of all the trees became covered with colonies in about four months after infection by which time a few aphids also migrated to the roots and settled down there. The trees were allowed to grow till October 1939, when they were uprooted and the number of galls formed on the roots of each of them was counted.

The experiment was repeated in the two subsequent years and the average number of galls formed on the roots of each tree in the three types of soils is given in Table VII.

TABLE VII

Average number of galls on roots of plants in three types of soils during 1939-41

Year of observation	Clayey	Sandy	Humus-rich
1939	23.0	10.0	13.0
1940	1.3	1.2	7.0
1941	18.0	6.3	12.0

No definite conclusions can be drawn from the data given in Table VII. It is, however, indicated that in the first and the third years of the trial, comparatively more galls were formed on the roots in clayey soil than in others but there is no significant difference between any two soils in any year. As the aphid attacks the under-ground parts of the plant up to a few inches of depth only, the incidence of attack on the root system must depend on whether or not it is near to the surface. It has been observed that as the root goes deeper into the soil, the aphids leave it but the same root

may again be attacked lower down on the steep slopes if it comes near the surface or becomes exposed. Thus on steep slopes a root may be attacked on three or four isolated spots. It appears that root infection is dependent on good aeration of the top few inches of the soil. Therefore, a slightly heavier infestation in clayey soil may be due to the cracking of the soil, thereby allowing the aphids easy access to the roots and plenty of aeration.

SUMMARY

1. The woolly aphid in Kamaun, as in the Punjab, is confined to apple trees and is viviparous, parthenogenetic and multibrooded.

2. The pest is active from March till about the middle of December. The maximum population is maximum in May and June and again in October, November and the first fortnight of December. After December mostly nymphs occur, concealed in cracks of barks and other sheltered situations on the trees. Winged aphids are produced during July and August which fly to other trees and start new colonies. Heavily infested trees show greater proportion of winged to wingless aphids.

3. Migration of the woolly aphid from shoots to roots and vice versa occurs practically all the year round. Upward and downward migrations are accentuated during the hottest and the coldest parts of the year, respectively. At other times, migrations appear to be independent of the weather conditions, being governed largely by the necessity of seeking suitable places to settle down.

4. The reproduction of the woolly aphid is not adversely affected by temperatures up to 90°F. Below 37°F., reproduction ceases. Excessive humidity, usually occurring during July-September retards the multiplication of the pest.

5. The woolly aphid in Kamaun is attacked by two predators, *Syrphus confrater* Wied. and *Coccinella septempunctata* Linn. The former is of little economic importance but the latter exercises effective check in certain areas from March to the end of June. Efforts at establishing the parasite, *Aphelinus mali* Hald., have not yet succeeded.

6. Observations are recorded on the behaviour of different varieties of apple trees to the attack of the woolly aphid.

7. Experiments on the inter-action of stocks and scions with respect to woolly aphid attack showed that the resistance or susceptibility of a variety is not influenced by its union with another variety possessing the reverse characteristic.

ACKNOWLEDGEMENTS

The work described in the present paper was, in part, financed by the Imperial Council of Agricultural Research. It was initially started, with the assistance of one of us (R. N. S.), by Mr. P. B. Richards, formerly Entomologist to Government, U. P. The authors feel indebted both, to the Council and to Mr Richards for their respective contributions to the work.

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FIG. 1. Lesions (early stage) on the leaf of *Ficus carica*.

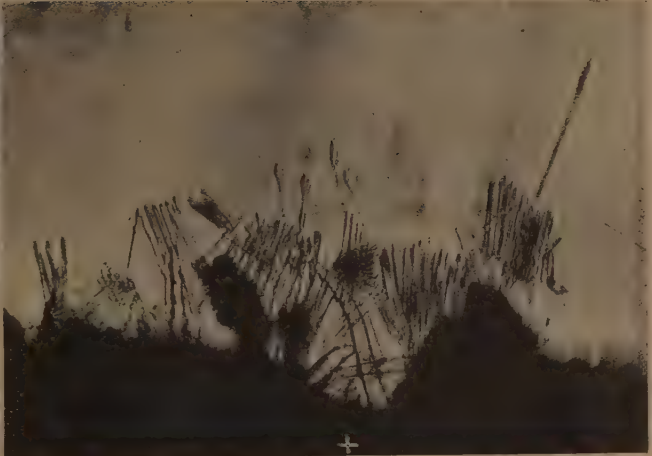


FIG. 2. Photomicrograph of the affected margin of leaf showing the spear like branches bearing bundles of conidia.



FIG. 3. Photomicrograph showing the structure of the spear like main branch with lateral monopodial branchlets (conidiophores)



FIG. 4. Section of a leaf showing a few conidia still attached at the tip of the monopodial branchlets.

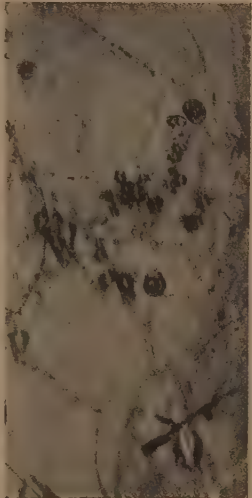


FIG. 5. Chlamydospores.

A LEAF-SPOT DISEASE OF FIG (*FICUS CARICA* L.) CAUSED BY *CYLINDROCLADIUM SCOPARIUM* MORG

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(Received for publication on 6 February 1947)

(With Plate XV)

A LEAF-SPOT disease of *Ficus carica* L. was observed at Cawnpore, during 1945 in the rainy season. In 1946 the disease was again noticed at the beginning of July. The severity of the attack and the prominence of the lesions warranted investigation. Preliminary examinations revealed the presence of a fungus hitherto unrecorded from India. The fungus has been determined to belong to the Genus *Cylindrocladium*.

SYMPTOMS

At the commencement of the rains in the beginning of July, minute dot like brown spots up to 2 mm. across appear scattered on both surfaces of the leaf. These enlarge into prominent reddish brown spots measuring up to 30—40 mm. across. Sometimes the spots are partially limited by the veinlets, giving them an irregular appearance (Plate XV, fig. 1). The margin of the spots is dark brown and the colour is deeper where the margin happens to run along the veins. The veinlets within the patches are also prominently brown coloured. Some spots are light brown in the centre while others show a zonate appearance, especially on the upper surface. In most cases the spots coalesce and form irregular patches which may involve greater part of the leaf area. Shot-holes may appear in the centre of the old lesions. Sometimes the affected parts on the margin become brittle and break away. During humid weather the lower surface gets covered by a cobweb like mycelium which subsequently appears powdery. Infection was not noticed on other part of the host plant.

MORPHOLOGY OF THE FUNGUS

Mycelium. The mycelium is mainly intercellular. The hyphae are colourless, slender, septate and branched, and 3·5—6 μ in diameter. Older hyphae tend to become brown. The affected cells turn brown and are killed giving rise to the typical spots. The xylem vessels are not usually penetrated but the vascular bundles become deep brown.

Conidia. In moist weather the affected areas produce, mostly on their lower surface, septate, erect, spear like main branch 230—355 μ long and 3·5—6 μ broad at the basal region and 1·4—2·8 μ at their upper region. These come out singly or in clusters of 2—4 or more through the stomatal opening or directly through or between the epidermal cells. They are also produced on the aerial mycelium in the moist chambers. The apical cell of these main branches is characteristically swollen into a spear-head like structure, measuring 17—20 μ by 7—10 μ . These main branches bear one or more monopodial fertile secondary branches at various heights, mostly on the lower one-third part of their length. Viewed under the low power of the microscope these appear like slender, stalked, penicillate structures, each bearing a white shining head composed of a bundle of elongate conidia (Plate XV, fig 2). When mounted in water or lacto-phenol, the mature conidia get detached and their structure is then clearly seen (Plate XV, figs. 3 and 4). Each fertile branch is cymosely divided one to three times; the ultimate branch or the sterigmata bears a cylindrical bicelled conidium (Plate XV, fig. 4). These lateral branches (or conidiophores) exclusive of the spores, measure 60—125 μ . Sometimes the spear like main branch is absent and only the penicillate fertile head is produced. Occasionally a lateral branch, ending in spear-like terminal cell arises from the main spear-branch and bears the fructifications. The bicelled conidia have rounded ends, measuring 32·4—50·4 μ by 3·4 μ at the apex and 3 μ at the base. These germinate readily in water producing one germ tube from each of the cells; generally they come out of the ends but may be formed from any other part also. One of the germ tubes is produced earlier than the other.

Chlamydospores. In moist chambers sometimes the cells of the aerial hyphae swell up and become beaded. These enlarge and become light brown and form round or irregular chlamydospores up to 30μ in diameter. When kept in water they germinate by giving out germ tubes (Plate XV fig. 5).

GROWTH IN CULTURE

The fungus has been isolated in culture. On potato glucose agar it grows out uniformly forming a white circular colony and gradually becomes golden brown. The colour deepens and numerous sclerotia appear. The latter are composed of dark brown thick walled pseudoparenchymatous cells that resemble the chlamydospores in structure. The size of the sclerotia extends up to 0.8 mm. in diameter. At this stage chlamydospores are also seen under the microscope. These resemble those formed on the leaves kept in moist chambers and measure up to 40μ in diameter. None of these cultures have produced conidia even after one month.

PARASITISM

The parasitic nature of the fungus has been established by inoculating both the surfaces of the leaves with conidial suspension obtained from the leaves kept in moist chambers for 24 hours, and also by putting bits of mycelium from the culture tubes and covering the latter with cotton pads moistened with sterilized water. The infection experiments were undertaken on humid and cloudy days during the month of August and September. More than 200 leaves were inoculated and about ninety per cent. of the leaves got readily infected by both the methods. Characteristic lesions were produced within seven days and the fructifications appeared after two weeks. The infected leaves are shed 20–30 days earlier than the healthy ones. Moist weather is essential for infection. It was also noted that the fully mature leaves are most susceptible. After October new leaves appear on the fig plants but these do not show any sign of the disease till the next rainy season. It thus appears that the fungus is a weak parasite attacking fully mature leaves which are in a low state of vitality prior to their being shed naturally after the rains.

IDENTITY OF THE FUNGUS

The Genus *Cylindrocladium* was first recorded and described by Morgan [1892]. Subsequently it was found on the dead leaves of papaw plant by Ellis and Everhart [1900]. The parasitic nature of the fungus was established by Massey [1917]. Recently the fungus has been recorded in England by Wormald [1944] on several members of the family Rosaceae. Anderson [1918] carried out detailed investigations on the morphology and parasitism of *C. scoparium* Morg. causing the crown canker of rose. The same author isolated another species from rose, *C. parvum* And., with smaller spores. Another new species of the genus *C. macrosporum* has since been recorded by Sherbakoff [1928] on a palm. Dodge [1940] has also recently reported a species *C. pteridis* on fern. Rea and Hawley [1912] had described and created a new genus *Candelospora*. According to Fawcett and Klotz [1937] the genus *Candelospora* resembles the genus *Cylindrocladium* in the structure of the fructification but differs from the latter in having three septate conidia.

The species appearing on *Ficus carica* has one septate conidia and the measurements of the conidiphores and conidia approximate the species *Cylindrocladium scoparium* Morg. The dimensions of the conidia given by the various authors are as follows:

Morgan (1892)	. . . . .	$40-50 \times 4\mu$ at the apex, and 3μ at the base
Ellis and Everhart (1900)	. . . . .	$40-50 \times 4.5\mu$
Massey (1917)	. . . . .	$36-55 \times 3.3-4.51\mu$
Anderson (1918)	. . . . .	$48.8 \times 5.1\mu$
Wormald (1944)	. . . . .	$41-64 \times 4-6\mu$
Present authors on <i>Ficus carica</i>	. . . . .	$32.4-50.4\mu \times 3.4\mu$ at the apex and 3μ at the base

The fungus causing the leaf-spot disease of *Ficus carica* is therefore *C. scoparium* Morg. So far this fungus has not been reported on the above host. This disease and the genus of the causal organism is a new record for India.

SUMMARY

1. During the rainy season a leaf-spot disease of *Ficus carica* L. was noticed at Cawnpore. The attack was severe and confined to the leaves.
2. Minute brown dots appeared on both surfaces of the leaves and enlarged into irregular spots. In most cases these coalesced and covered greater part of the leaf area. Shot-holes often appeared in the old lesions.
3. The hyphae of the fungus causing the disease was mostly intercellular, septate and branched. Characteristic spear-like branches came out of the surfaces of the leaves. Each had one or more monopodial secondary penicilloid branches with a bundle of bicelled, elongated, cylindrical and hyaline conidia at the tip. The conidia measured $32.4-50.4\mu$ by 3.4μ at the apex and 3μ at the base. Chlamydospores were also observed.
4. The fungus was isolated in culture. Infection experiments on healthy leaves were conducted and fructifications appeared after a fortnight.
5. The identity of the fungus is discussed, and identified as *Cylindrocladium scoparium* Morgan. It is a genus hitherto unrecorded from India.

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THE ROLE OF 'CUTTINGS' IN THE DISSEMINATION OF FOOT-ROT OF PIPER BETEL

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FOOT-ROT, caused by *Phytophthora parasitica* var. *piperina* Dast., is the most serious disease of betel-vine in the Central Provinces and Berar. The disease was first reported in the province in 1923 and since then it has gradually increased with the result that at present the cultivation of the vines has been practically abandoned. In the early stages of infection external symptoms of the disease are general pallor, loss of lustre and drooping of tender shoots and leaves without any external sign of rotting or lesions on any of the aerial parts. Later on the whole plant turns yellow and dries off. Roots and underground parts of the stem rot and are destroyed. The disease has been found to be soil borne as well as 'seed' borne.

The dissemination of foot-rot through cuttings, so called 'seed', has so far not been systemically and thoroughly investigated. Mc Rae [1934] and Dastur [1935] are of opinion that the disease is soilborne but Chowdhry [1944] considers it to be seedborne as well, the pathogen being inside the cuttings. The experiments conducted by Chowdhry give only indirect indications as to the mode of dissemination, as neither the soil nor the cuttings were sterilized before planting. As such it could not be definitely concluded that the pathogen resides as dormant mycelium inside the planting setts and the disease is carried through them from place to place. It is probable that the fungus might have been carried externally on the cuttings or might have been present in the soil.

Continuous observations of several years in the past have shown that if an old garden is replanted, leaf-rot and foot-rot, both caused by *Phytophthora parasitica* var. *piperina* Dast., appear more or less simultaneously, after two or three months of plantation. If, however, a garden is raised on a land where betel-vine was never cultivated for several decades, leaf-rot invariably appears six or seven months earlier than foot-rot. It was further observed that the foci of infection for foot-rot were at places where leaf-rot appeared. In such cases the foot-rot infection spread along and across the betel-vine lines from the foci either due to falling of the diseased leaves on the soil below or due to the practice of lowering of the vines where they are first taken off the bamboo stakes, spread on the ground and then taken up and retied. In both the cases the fungus mycelium thus contaminating the soil, attack the roots of the vines and cause foot-rot. These observations gave an indication that in the case of replanting old gardens the infection was mostly from the soil, whereas in the gardens on soils without any previous history of *pan* cultivation the infection was mainly from the cuttings. In the latter case the fungus was carried by the cuttings and it first produced leaf-rot disease under favourable conditions of temperature and humidity.

The above observations were verified by conducting experiments in pots with sterilized soil. A year-old betel-vines of *kapuri* and *bangla* varieties were secured for seed purpose from a garden severely affected by the foot-rot disease. Each of these vines was cut from tip downwards into six pieces, each consisting of five or six internodes and measuring from 12 to 15 in. in length. In the text these pieces have been referred from tip downwards in order of succession as 1st, 2nd — — and 6th cuttings respectively. As per cultivation practices only three leaves were left on 1st to 4th cuttings while 5th and 6th were without leaves as they had none on them. Sixty unsterilized cuttings of each of the two varieties were sown as such on 4 November 1942, in pots with sterilized soil, one in each. In the other series, arrangements similar to the above were made but the same number of cuttings of the two varieties were sown after sterilizing them by dipping in 2 : 2 : 50 strength Bordeaux mixture for one hour. The experiments were duplicated and the observations were recorded every day for two years. The dates of the appearance of leaf-rot and foot-rot diseases in the unsterilized cuttings of both the varieties, *kapuri* and *bangla*, are given in Table I.

TABLE I
Dates of appearance of leaf-rot and foot-rot in unsterilized cuttings

Cuttings	No. of plants affected	Kapuri		Bangla	
		Leaf-rot	Foot-rot	Leaf-rot	Foot-rot
First	1	7-1-43	After 2 years	9-12-42	13-7-44
	2	11-1-43	5-7-44	21-12-42	After 2 years
Second	1	23-12-42	24-10-43	3-12-42	17-10-43
	2	3-1-43	23-12-44	11-12-42	After 2 years
	3	5-1-43	After 2 years	13-12-42	27-7-44
	4	11-12-43	17-3-44	19-12-42	After 2 years
Third	1	7-1-43	After 2 years	17-12-42	13-11-44
	2	17-12-43	do.	7-1-43	12-2-44
Fourth	1	17-12-42	2-8-44	7-12-42	27-9-43
	2	11-1-43	29-4-44	9-12-42	After 2 years
	3	..	..	13-1-43	do.
	4	..	..	27-1-43	7-8-44
Fifth	1	Did not appear	2-9-43	Did not appear	2-7-43
	2	do.	11-9-43	do.	21-7-43
Sixth	1	Did not appear	19-2-43	Did not appear	11-2-43
	2	do.	23-2-43	do.	21-2-43
	3	do.	3-3-43	do.	23-2-43
	4	do.	23-3-43	do.	5-3-43
	5	do.	4-7-43	do.	28-3-43
	6	do.	11-7-43	do.	7-7-43
	7	do.	3-8-43	do.	11-8-43
	8	do.	5-8-43	do.	13-8-43
	9	do.	9-8-43	do.	27-8-43
	10	do.	11-8-43	do.	27-8-43

It will be observed from Table I that in the first four cuttings of both the varieties leaf-rot disease always appeared earlier than foot-rot. All the ten plants raised from the 6th cuttings and two of the 5th of each variety died due to foot-rot disease though there was no incidence of leaf-rot. The first incidence of leaf-rot was recorded just after a month of sowing while foot-rot appeared after three months and the infection went up to 45 per cent within five months.

In the second series, where the cutting were treated with 2 : 2 : 50 strength Bordeaux mixture for one hour before sowing there was not a single case of leaf-rot disease in any of the cuttings. The 1st, 2nd, 3rd, and 4th cuttings were neither affected by leaf-rot disease nor by foot-rot. Three plants raised from the 5th cutting, one of *kapuri* and two of *bangla*, were observed to be affected only by foot-rot disease on 13-7-43, 27-7-43 and 21-8-43 respectively. This effect was more pronounced in the plants raised from 6th cutting where foot-rot disease appeared in all the plants and killed them. The first appearance of foot-rot disease in the plants raised from the 6th cutting was after three months of sowing while in the 5th cutting after eight months.

From the above experiments it could, therefore, be inferred that in the case of 1st to 4th cuttings, which are generally used for 'seed' purposes, the pathogen was borne externally and not carried internally, as otherwise after surface sterilization they should have given foot-rot disease as in the 6th cutting. Further, it was found that *Phytophthora parasitica* var. *piperina* Dast. is also carried internally in the lowermost cutting, mostly in the last one, as in spite of surface sterilization the foot-rot disease appeared just after three months of sowing. It may, however, be mentioned that in actual cultivation practice the lowermost two or three cuttings of the vines are never used for 'seed' purposes as the vines from these remain stunted in growth and do not produce leaves of any economic value. The first four cuttings give luxuriant growth and the vines yield leaves which fetch high price

in market. When these cuttings were treated with Bordeaux mixture (2 : 2 : 50) for an hour before sowing they did not exhibit any sign of leaf-rot or foot-rot diseases as mentioned above, thus indicating that the pathogen was not carried internally but only externally. The untreated cuttings were affected by both the diseases, first by leaf-rot and later by foot-rot, the former appearing after a month of sowing and the latter on the same affected plants after a duration of seven months to two years. In such cases the pathogen was carried externally, invariably on leaves, causing leaf-rot, and these infected leaves spread the infection to the soil when they fell on it, which in its turns attacked the roots of the vines causing foot-rot. The roots were invariably attacked least one inch below the ground level. The leaves and roots were attacked by fungal mycelium and artificially the parasitism could be established in cent per cent cases. Repeated thorough searches could not reveal the presence of zoospores on roots, stems and leaves. Fungal mycelium could be invariably observed internally in the 6th cuttings, rarely in the 5th and never in the first four cuttings.

I am thankful to Mr. K. A. Mahmud, B. Sc., for his help during the course of this study.

SUMMARY

1. Both foot-rot and leaf-rot diseases of betel-vine are caused by *Phytophthora parasitica* var. *piperina* Dast.

2. Cuttings obtained from an infected garden when planted in a new bareja first give leaf-rot which is followed by foot-rot. Both the diseases appear practically simultaneously if an old garden is replanted. In the first case the foot-rot disease is due to infected cuttings while in the latter it is caused by the infected soil as well as by the cuttings.

3. The pathogen is disseminated by cuttings from place to place; it being borne only externally in the first four top cuttings and internally as well in the lower ones.

4. The dissemination of the leaf-rot and foot-rot diseases to new gardens can be effectively controlled by the use of only first four cuttings and by treating them with 2 : 2 : 50 strength Bordeaux mixture for one hour before planting.

5. Cuttings should not be taken below five feet from the top of a vine as in an infected garden the fungal mycelium is carried inside the tissue of the lower cuttings.

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DETERMINATION OF PRESSURE IN SEALED CANS BY THE SPHEROMETER

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(With two text figures)

IN EXPERIMENTS on the preservation of food in sealed cans it is often necessary to determine the change in pressure inside the cans. The change may be caused by the formation of hydrogen gas, spoilage due to yeasts or any other cause. Sample lots of about half dozen cans are drawn at random from the experimental pack, after different periods of storage, and pressure is determined with a gauge after piercing the can cover. The cans thus opened served once, and once only, so far as the development of pressure in the pack is concerned. What is actually obtained is the pressure in a number of cans opened after varying intervals, or stored long enough to reach a condition where half the cans showed swelling due to pressure. From this the condition of the pack is inferred. The method is obviously defective because the initial vacuum, which is of primary importance, is not known except in cans opened at the time of packing and which are no more a part of the pack. Further due to great variation in the condition of the tinned surface, individual cans give out different amounts of hydrogen and consequently develop different pressures, even when headspace is the same in all cans. The ideal thing would be to know the pressure in all the experimental cans, at the beginning, during, and at the end of the storage period. To attain this object, Adam and Stanworth [1934] suggested the use of the spherometer. The original paper was unobtainable, but a reference to it in a later publication [Adam, 1942] was seen and a method developed independently. After this work was almost completed Adam [1943] has given further details about the method. But neither is the method of measurement completely described, nor are any figures given to enable the reader to find out the pressure in any set of cans. The simple method developed in these laboratories is, therefore, described.

Pressure develops most commonly only in fruit packs because of the highly acidic nature of the contents. As the size most popular with the fruit packers in India and abroad, is A2, figures for this size only have been obtained. The bigger size (A2½) is also used to some extent ; but inclusion of figures for both sizes would have increased the statistical work too much for this short paper. For those interested the method given points the way as to how figures can be obtained for any other size which they may be using. The dimensions of the two sizes mentioned are well known to the trade but are given here for ready reference.

TABLE I
Dimensions of the two can sizes

Size No. (cylindrical)	Height in inches		Diameter in inches		Capacity in c.c.	Remarks
	Inner	Outer closed	Internal	External at the rim		
A2	4.3	4.4	3.2	3.4	550	Tin plate of 100 lb. 'substance'
A2½	4.5	4.6	3.9	4.1	750	

The apparatus used is shown in Fig. 1. It consisted of a can A of which the two ends were properly closed and a copper tube 15 mm. long and 5 mm. bore was soldered at the middle of the cylindrical portion. The can was connected through a mercury manometer B and stop cock C to a larger bottle in which pressure could be raised or lowered at will. A plane glass plate with a 10 mm. hole in the centre was placed on the can. By placing a spherometer on the glass plate, the distance between the lower plane of the glass plate, (i.e. the upper plane of the rim of the can) and the centre of the

can cover was determined. Another reading was taken for the other side by inverting the can. The sum of the two readings was called the distance of the can cover from the plane of the rim. This is briefly referred to as "the distance" in the remainder of this paper. The spherometer was sensitive to 0.0025 mm. but readings were taken correctly only up to 0.005 mm. (*i.e.* one division on

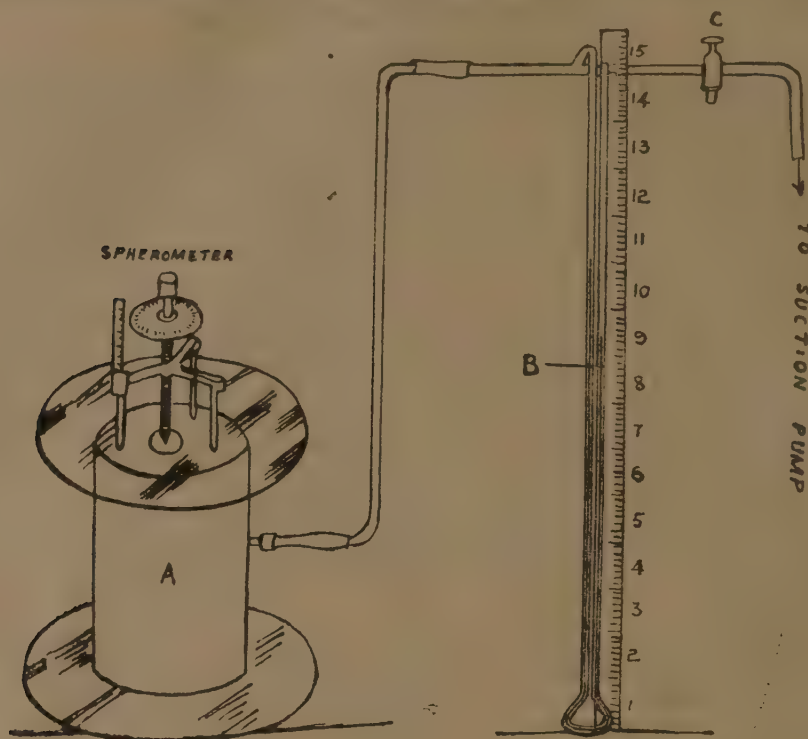


FIG. 1

the spherometer disc) because the variations due to other causes are much larger than this and it was thought unnecessary to take the readings more accurately. The legs of the spherometer were placed symmetrically with regard to the expansion rings so that the spherometer screw contacted, as near as possible, in the centre of the cover. The point of contact was determined electrically with a battery and a bell. One of the electric wires was placed under the can and the other momentarily brought in contact with the spherometer to see if contact had been established. By varying the pressure in the can from 12 inches above to 12 inches below that of the surrounding atmosphere twenty-five readings of distance were obtained for each can. Twenty-three A2 cans were studied. The mean distance (in microns) at different pressure is given in Table II.

Only the mean distance of the cans is given, because mention of all the 23 cans would give 23 such tables. However, statistical analysis of the cans was done individually also, but the variation among cans for the same pressure was of a much lower order of magnitude compared to the differences caused by the pressure. At zero pressure difference, the variation of distance among cans was insignificant compared to the change by one inch increase, or decrease, of pressure. This shows that, the standard can closing machinery gives the same type of can, so far as the distance of the covers from the plane of the rim is concerned.

The standard deviation of the distance is shown in the third column. The variation between cans in response to change of pressure is apparently of the same order up to a pressure of six inches above the atmospheric pressure. After this the covers begin to yield more rapidly to the pressure and slight differences in the seams or the thickness of the plate are likely to cause greater variations

among the cans. These latter were compared by the test and it was found that one inch change of pressure caused a significant variation in the distance at all pressures except the atmospheric pressure where the value is the lowest, though still significant. Table II further shows that the movement of the cover is much greater on the pressure side than on the vacuum side. This result is to be expected because of the greater restriction in the movement of the cover to the inside than to the outside.

TABLE II

Mean distance in A2 can and change caused by 1 in change of pressure at various pressures

Difference from atmospheric pressure in inches of Hg.	Distance (microns)			Change of Distance		
	Mean of 23 cans	Standard deviation	Calculated	Mean	S. E.	t
-12	9713	15.9	9657	..	..	..
-11	9637	16.0	9608	76	3.1	24
-10	9564	16.0	9535	73	4.9	14
-9	9491	14.1	9497	73	5.1	14
-8	9413	15.2	9433	78	3.8	20
-7	9330	14.2	9365	83	4.3	18
-6	9263	13.9	9291	67	5.4	12
-5	9179	13.1	9213	82	4.0	20
-4	9096	13.1	9130	83	3.8	21
-3	9009	13.3	9042	87	2.7	31
-2	8918	11.7	8049	91	4.6	29
-1	8820	14.2	8841	98	6.7	14
0	8752	12.2	8747	68	7.7	8
+ 1	8683	13.8	8683	110	11.2	6
2	8593	14.6	8526	121	4.6	23
3	8452	14.5	8408	129	6.1	19
4	8323	15.3	8286	132	4.9	26
5	8191	16.7	8158	142	4.8	27
6	8049	16.2	8025	145	6.7	21
7	7904	17.0	7884	158	5.7	25
8	7746	21.5	7744	165	10.7	15
9	7581	21.7	7597	159	8.1	19
10	7422	25.1	7444	159	11.9	14
11	7263	26.4	7286	159	6.8	23
12	7104	32.3	7124	157	10.0	15

The values of mean distance are plotted in Fig. 2.

The figure shows clearly the trend stated above that with increase of pressure above that of the atmosphere the curve diverges from the pressure axis. This characteristic property clearly indicates that the curve is anything but linear as stated by Adam in his latest publication [1943]. His conclusion is based only on the vacuum half of the curve. Increasing the range has brought out the true form of the curve. In fact this could be guessed from the following reasoning. As the vacuum increases, the time would come when the cover would cease to move inward, and conversely, as the pressure increases to 14-15 inches in case of A2, and to 7-8 inches in case of A2½ cans, there is a sudden rapid movement of the covers, the can bulges and what is known as doming takes place. This is the same as to say, that the curve tends to become parallel to the pressure axis as the vacuum increases and to the distance axis as the pressure increases. Taking pressure as independent and distance as the dependent variate, the method of the orthogonal polynomials was applied for fitting an equation to the curve. The sums of squares contributed by linear and quadratic regression are given in Table III.

Quadratic regression was significant. The equation connecting the distance with pressure was :

$$Y = 8747 - 105.5X - 2.5x^2 \dots \dots \dots (i)$$

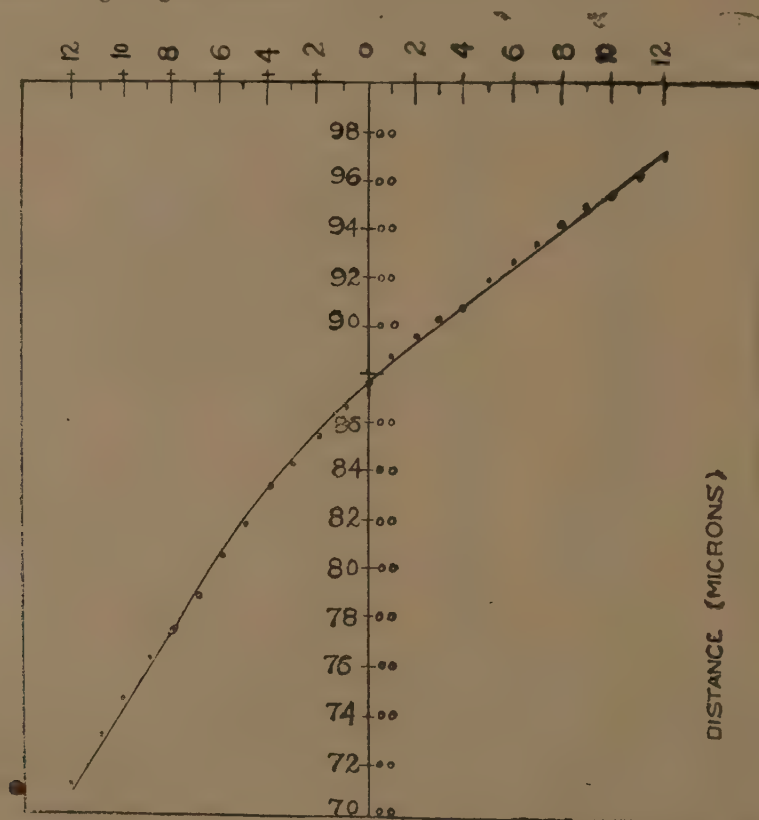
where Y is the distance (in microns) as defined above and x is the pressure difference, in inches of mercury, between the inside of the can and the surrounding atmosphere. The calculated values of the distance are given in the fourth column of Table II and are shown as black dots in Fig. 2. After

taking the reading for distance of any sealed can, the pressure can be read off from Fig. 2, or calculated more exactly, by the equation :—

$$X = \sqrt{944.2 - 0.4y} - 21.1 \dots\dots\dots (ii)$$

which is another form of equation (i). Only the positive value of the square root is to be taken for the calculation.

In order to test the accuracy of the method in practice a dozen cans were taken at random from a large lot and the distance measured. The pressure was then determined by the gauge method. The results are shown in Table IV. The agreement is reasonably good and the method can, therefore, be expected to give good results.



PRESSURE DIFFERENCE FROM ATMOSPHERIC (INCHES OF MERCURY)

FIG. 2.

TABLE III

The sums of squares contributed by linear and quadratic regressions

Variance due to	D. F.	Sum of squares	Mean square
Linear regression	1	14,482,828	14,482,828
Quadrate	1	330,851	330,851
Residual	22	22,713	1,032
Total	24	14,836,392	..

Significant at 1 per cent level

TABLE IV

The observed and calculated pressure in sealed cans

Serial No.	Distance in microns	Pressure calculated	Pressure found by gauge
1	8115	5	6.0
2	10245	-12	-11.5
3	10130	-12	-10.5
4	8320	4	4.0
5	9220	-6	-3.0
6	9455	-8	-6.5
7	8460	3	0.0
8	9575	-10	-9.5
9	9690	-12	-11.0
10	8610	2	2.0
11	7785	8	9.0
12	8770	0	0.0

SUMMARY

1. A procedure is suggested by which the relation between the pressure in a can and the distance between the plane of the rim and centre of the can cover can be determined. Only A2 cans have actually been studied, but the method is applicable to other similarly made sizes.

2. After statistical analysis and equation has been suggested for determining pressure from a reading of distance. The equation will be quadratic for other sizes also. Only the constants will be different.

3. Determination in a random lot has shown good agreement between observed and calculated results and the method can be recommended when large lots of cans are to be observed over long periods for a tendency to develop pressure due to hydrogen or fermentation.

ACKNOWLEDGEMENTS

The author wishes to thank S. B. Lal Singh, now Fruit Development Adviser to the Government of India, for his interest in the work while he was head of the Fruit Section in this Institute and to Mr. D. N. Nanda, Statistical Assistant to the Cotton Research Botanist for helping in the Statistical analysis.

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REVIEW

THE USE OF HETEROSIS IN THE PRODUCTION OF AGRICULTURAL AND HORTICULTURAL CROPS

By T. ASHTON, Imperial Bureau of Plant Breeding and Genetics publication—July 1946. Price 3s.

THE production of hybrid maize and its success in different parts of the United States of America constitute an achievement of very great importance. The exploitation of heterosis, which has engaged the attention of a number of workers, offers great economic possibilities in many crops including some self-pollinated ones.

The author of the bulletin has brought together the results obtained by different workers engaged in the study of heterosis with special reference to its utilization in agricultural and horticultural crop production. It is very difficult to deal in detail with all the work done on different crops in a small treatise like the one in question. The author has, however, presented a good deal of useful information which enables the reader to have an idea as to how heterosis can be exploited for commercial purposes.

The cost of seed production is one of the chief factors on which the commercial utilization of the phenomenon depends and, as such, its value is very limited in normally self-fertilized crops in which one flower produces one seed and artificial hybridization is difficult or laborious. The author has done well to mention the work carried out by different investigators to overcome these difficulties by attempting to find out male-sterile forms or by bulk emasculation as has been tried in Sorghum. Growing of bulk seed of some later generations has also been tried in a few cases.

Besides an introductory section wherein a mention has been made of the different explanations put forward by various workers for the phenomenon of heterosis, the bulletin is divided into four sections dealing with self-pollinated crops, cross-pollinated crops, a sexually-propagated plants and forest trees. Within each section, crop plants are treated individually. The extensive bibliography should be of help to all workers in the field.

The bulletin will be welcome to all those engaged in the practical application of hybrid vigour since no general publication on the subject has so far been available.—B. P. P.

PLANT QUARANTINE NOTIFICATIONS

Notification No. F.4-6/47-PP(SV), dated the 17th May 1947, of the Government of India in the Department of Agriculture

IN exercise of the powers conferred by Sub-section (1) of Section 3 of the Destructive Insects and Pests Act, 1914 (II of 1914), the Central Government is pleased to direct that the following further amendment shall be made in the notification of the Government of India in the late Department of Education, Health and Lands, No. F. 320/35-A, dated the 20th July 1936, namely :—

In the First Schedule appended to the said notification in column 3 for the words 'The Department of Agriculture' against the entry 'Holland' in column 2 the words 'The Director of Plant Protection Service at Wageningen' shall be substituted.

EXTRACT

Health certificates in respect of plant imports from Holland (Country of Origin) will in future be issued under the authority of 'The Director Plant Protection Service at Wageningen' and not of 'Department of Agriculture' as indicated in the first Schedule to Destructive Insects and Pests Act, 1914.

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References to literature, arranged alphabetically according to author's names, should be placed at the end of the article, the various references to each author being arranged chronologically. Each reference should contain the name of the author (with initials), the year of publication, title of the article, the abbreviated title of the publication, volume and page. In the text, the reference should be indicated by the author's name, followed by the year of publication enclosed in brackets; when the author's name occurs in the text,

the year of publication only need be given in brackets. If reference is made to several articles published by one author in a single year, these should be numbered in sequence and the number quoted after year both in the text and in the collected references.

If a paper has not been seen in original it is safe to state 'Original not seen'.

Sources of information should be specifically acknowledged.

As the format of the journals (has been standardized, the size adopted being crown quarto (about $7\frac{1}{8}$ in. \times $9\frac{5}{8}$ in. cut), no test-figure, when printed, should exceed $4\frac{1}{2}$ in. \times 5 in. Figures for plates should be so planned as to fill a crown quarto plate, the maximum space available for figures being $5\frac{3}{4}$ in. \times 8 in. exclusive of that for letter press printing.

Copies of detailed instructions can be had from the Secretary, Indian Council of Agricultural Research, New Delhi.